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First Vibrating Wire Monitor Measurements of a Hard X-ray Undulator Beam at the Advanced Photon Source

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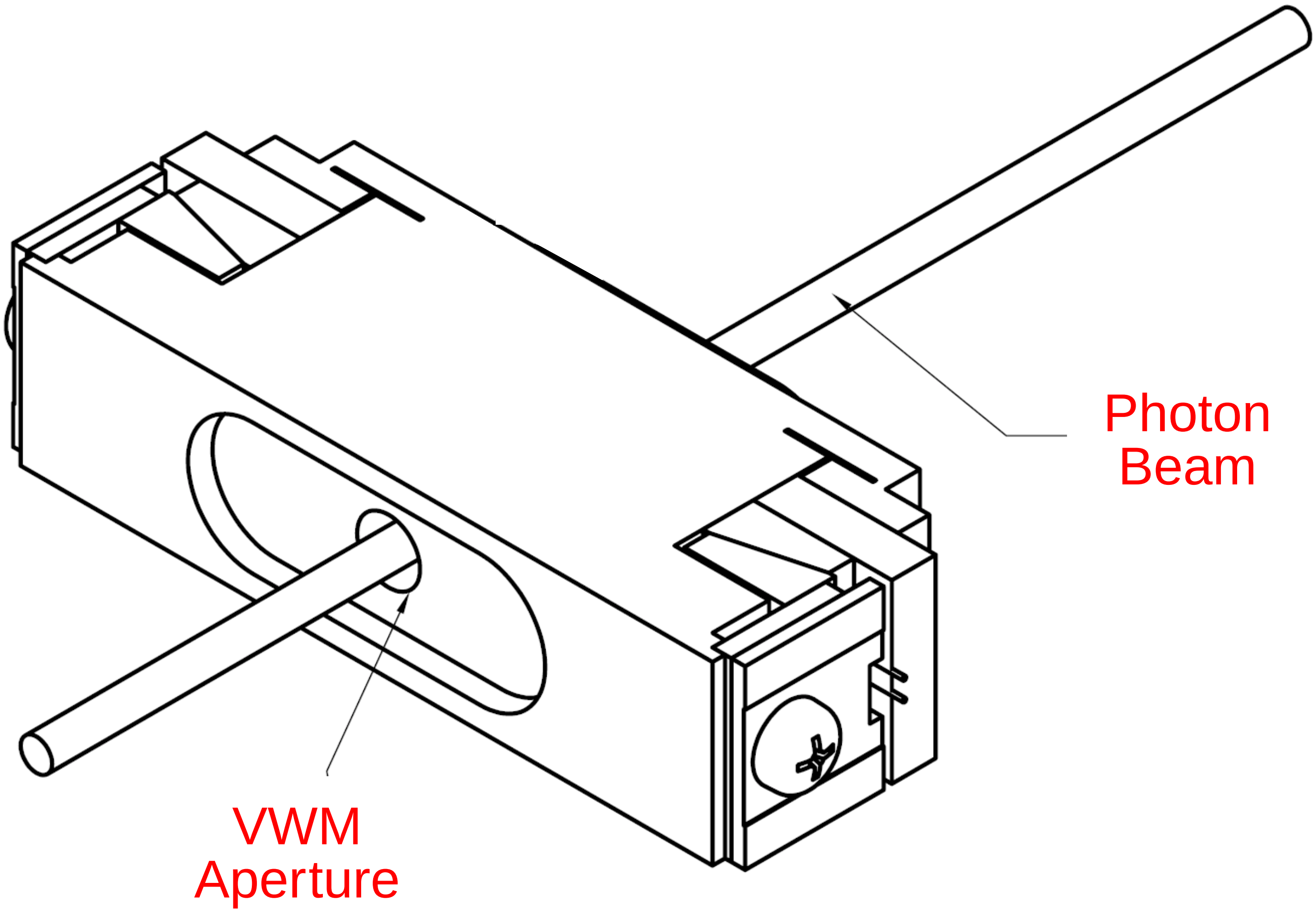
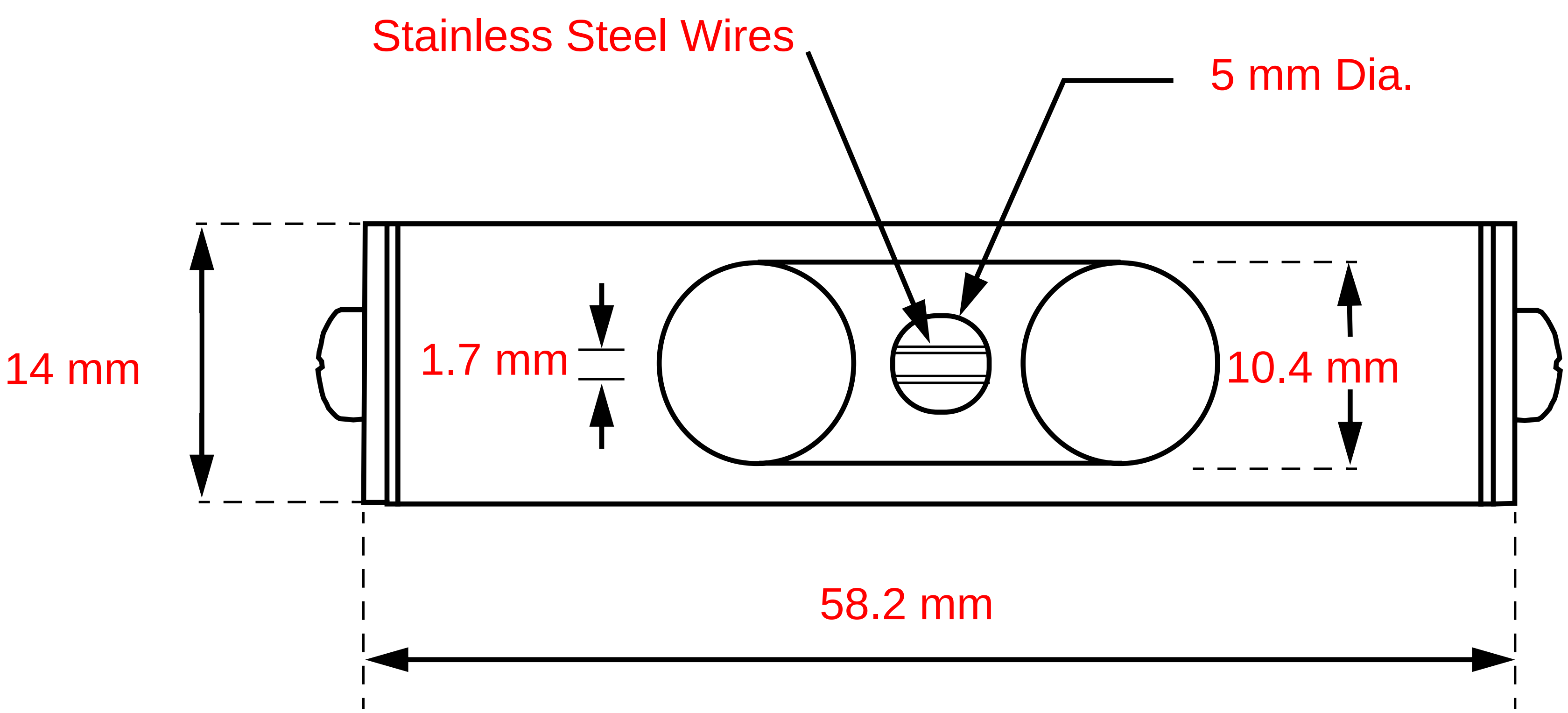
- Device Description
- Experiment Description
- Experiment Results
- Conclusions

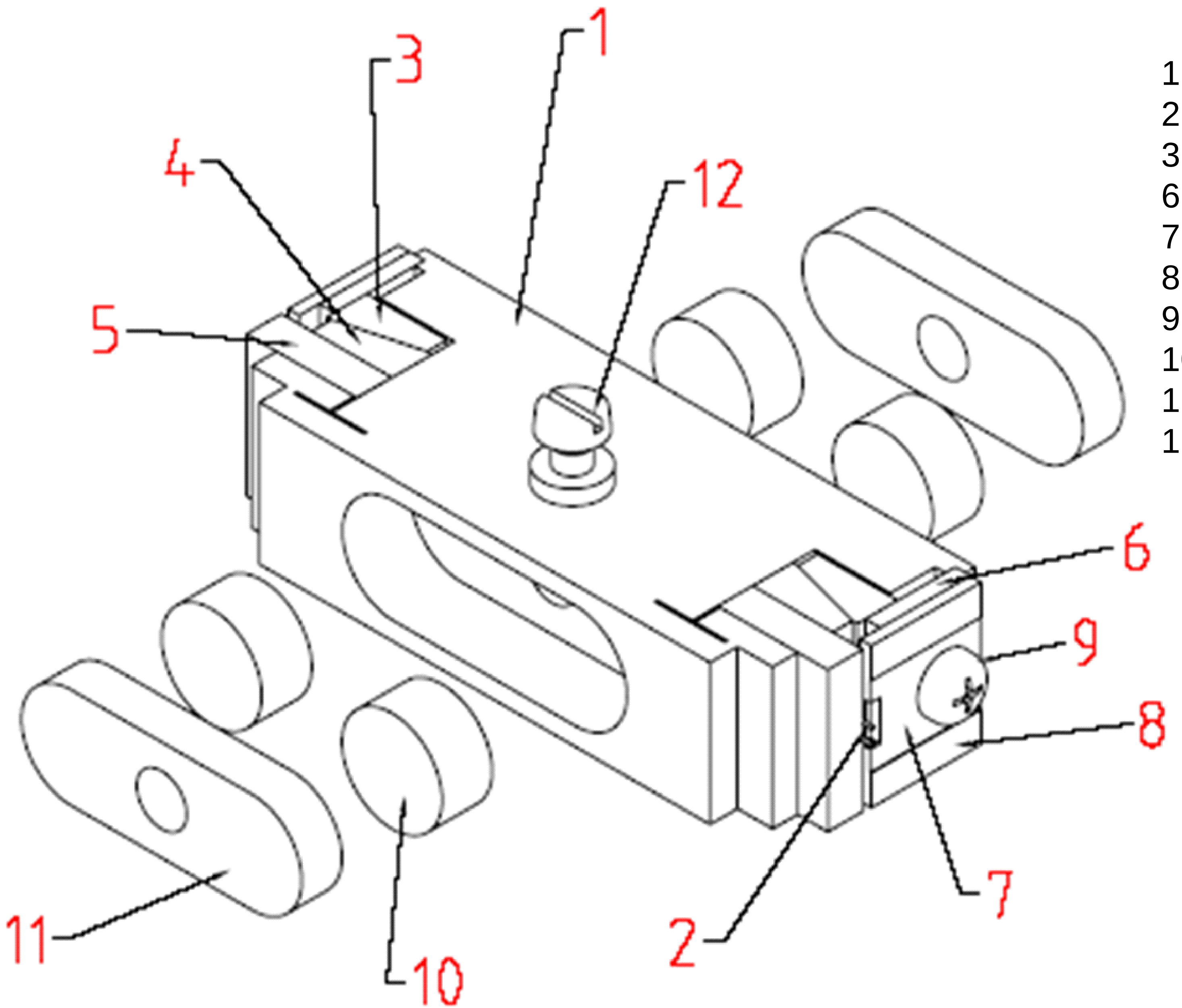
Vibrating wire monitor as tested



View along x-ray beam direction

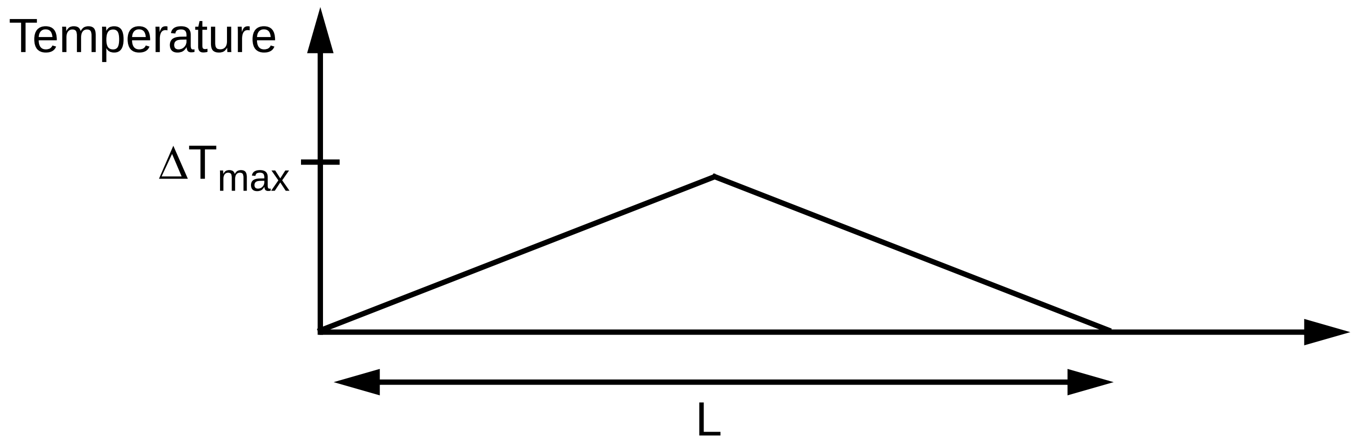


VWM Exploded View



1. VWM Base
2. Vibrating wires
3. 3, 4, 5. Fastening Parts
6. Fastening Plate
7. Contact Plate
8. . Soldering Surfaces
9. Screw
10. Permanent magnet
11. Magnet poles
12. VWM mounting screw

Wire temperature model - triangular profile



$$\Delta T_{max} = -4 \frac{f - f_0}{f_0 E \alpha_S} \sigma_0 ; \qquad \sigma_0 = f_0^2 L^2 \rho$$

$f - f_0$ = Frequency shift

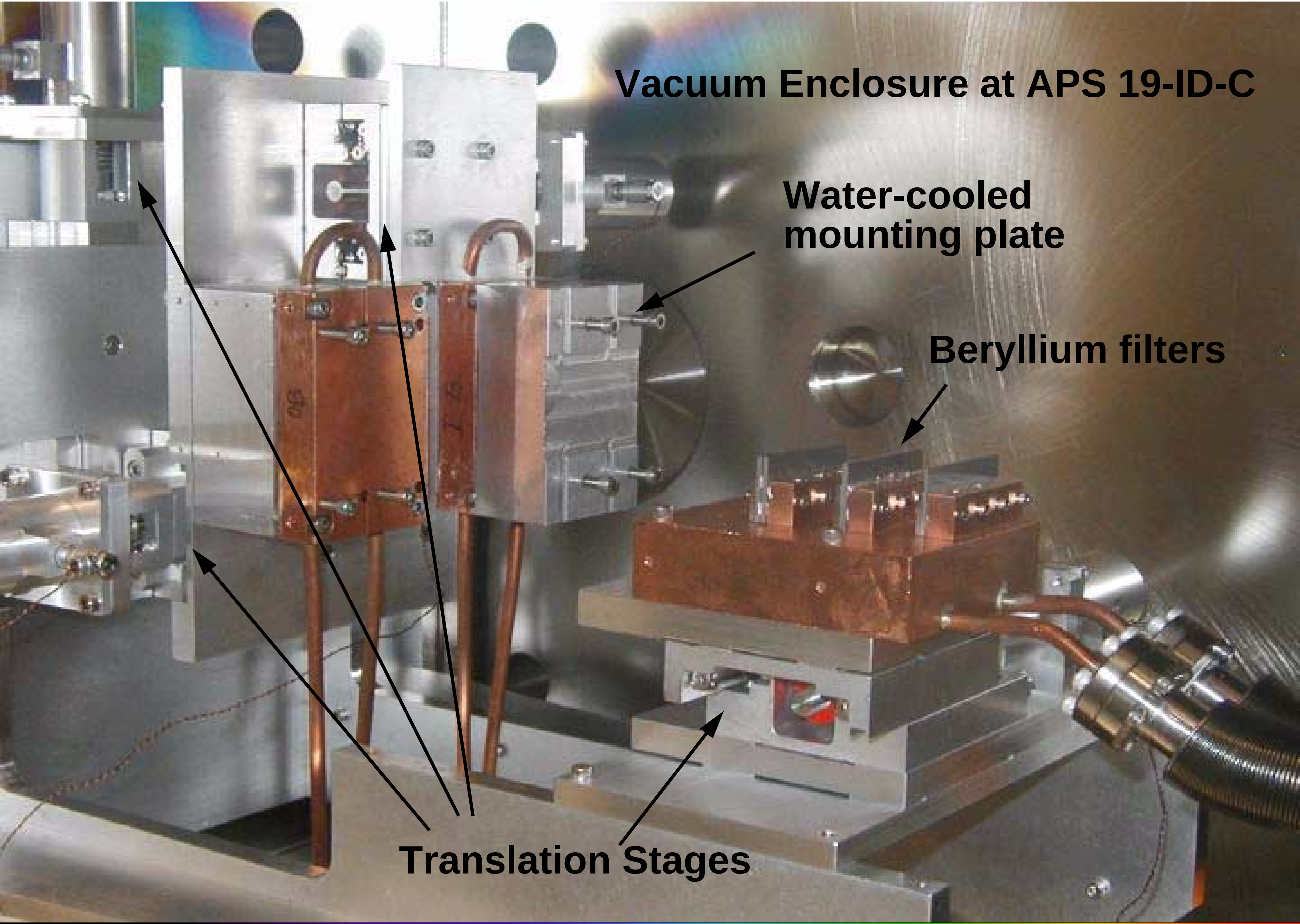
L = wire length = 3.6 cm

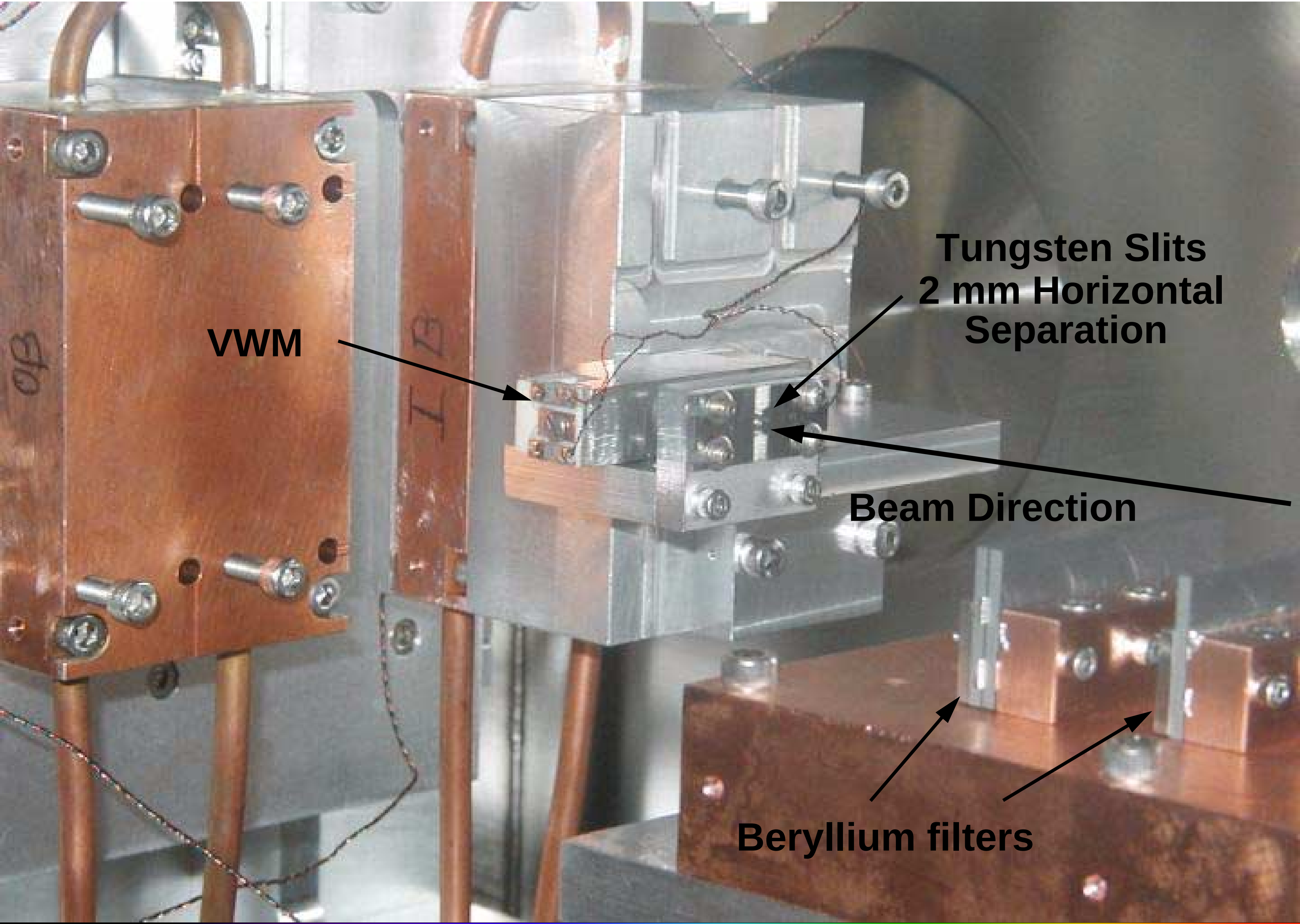
E = modulus of elasticity = 2e11 Pa, stainless steel

α_S = thermal expansion coefficient = 1.75e-5 K^{-1}

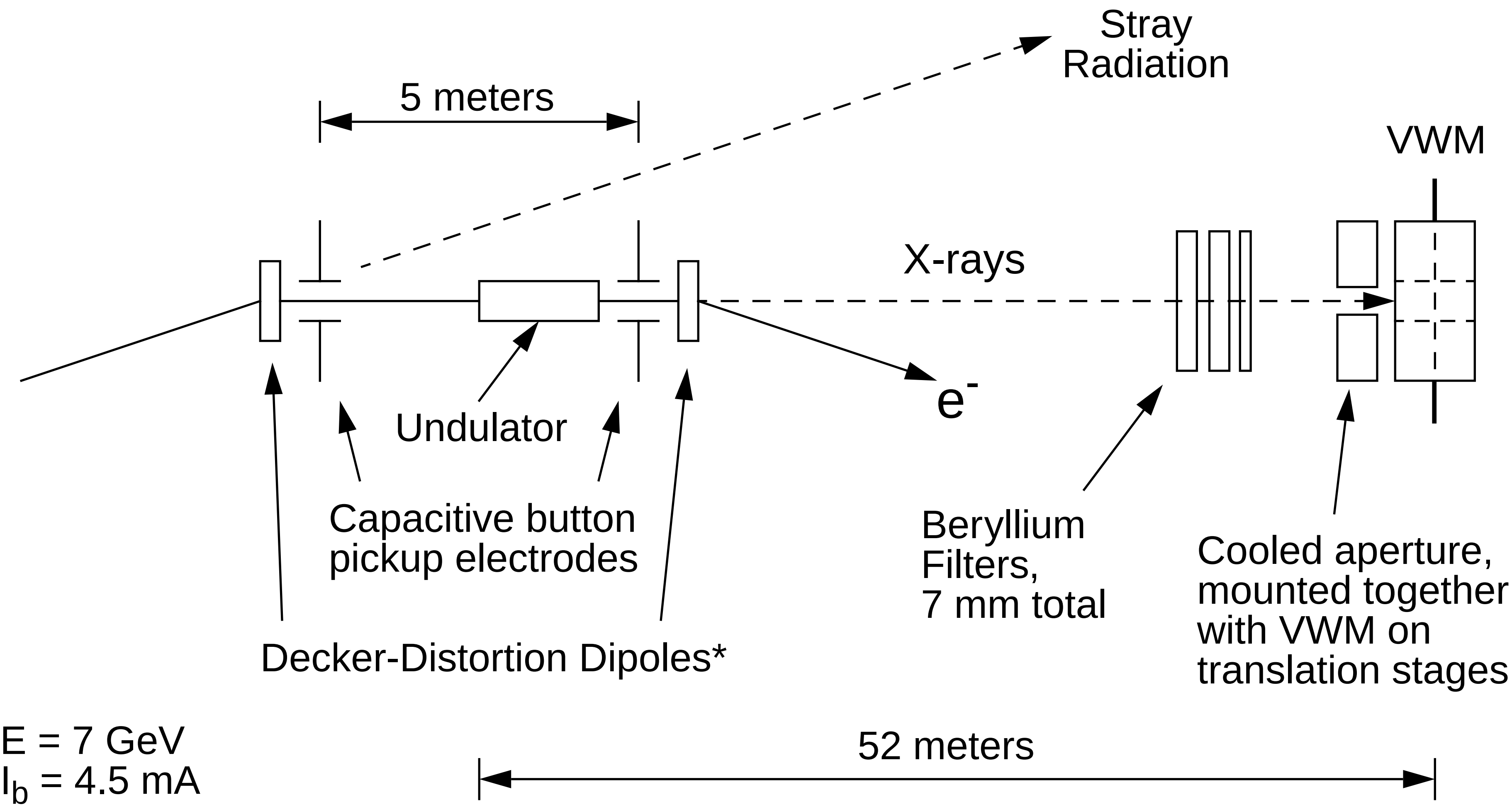
σ_0 = initial wire stress

ρ = wire density = 8e3 kg / m^3


Vacuum Enclosure at APS 19-ID-C
Water-cooled mounting plate
Beryllium filters
Translation Stages


Tungsten Slits
2 mm Horizontal
Separation
VWM
Beam Direction
Beryllium filters

Plan View of VWM@APS Experimental Arrangement



E = 7 GeV
I_b = 4.5 mA
APS Undulator type A,
Gap = 45 - 80 mm
(normal range 11 - 30 mm)

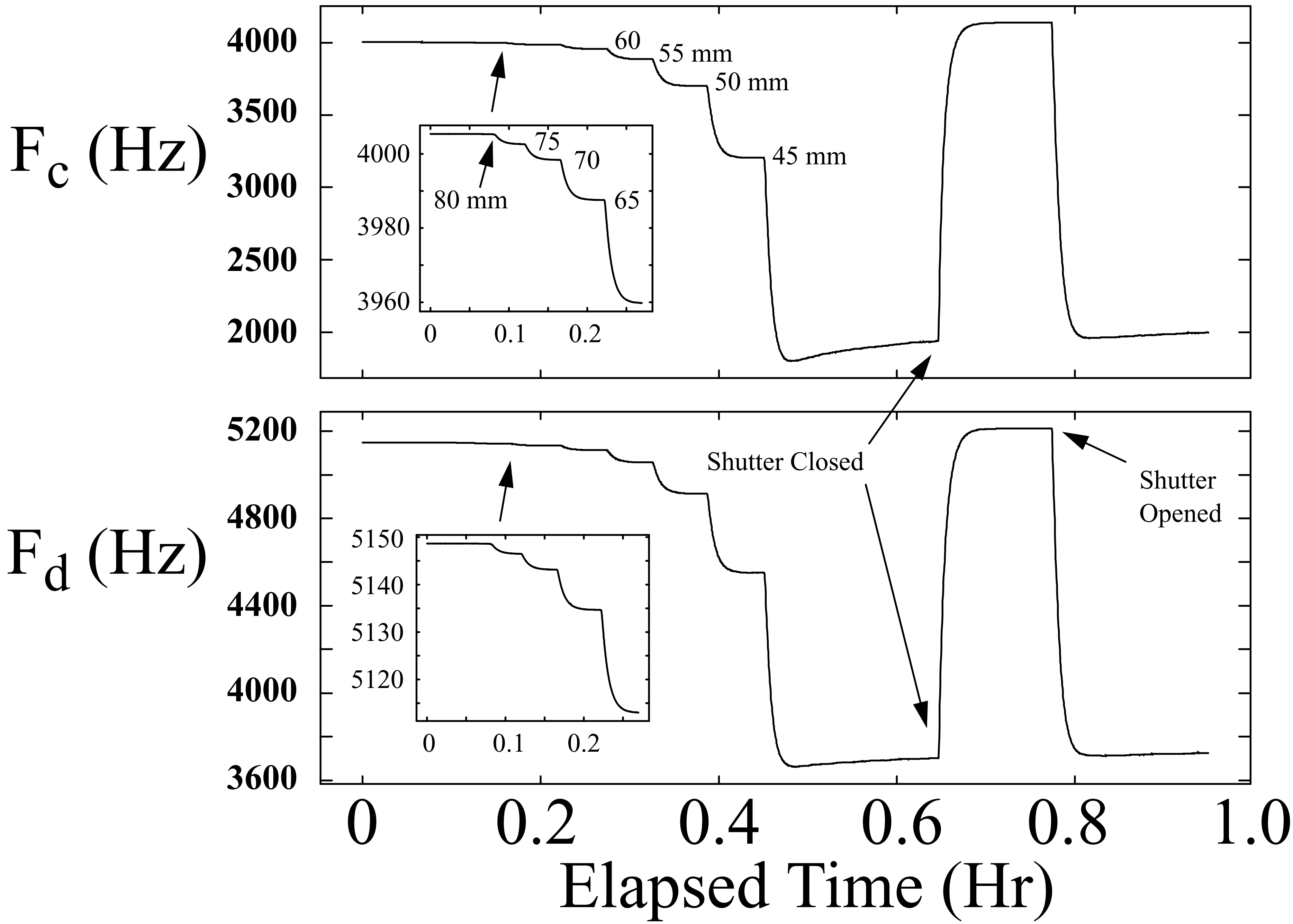
* G. Decker, O. Singh, *Phys. Rev. ST Accel. Beams* **2**, 11208 (1999).

Power levels for APS Undulator A

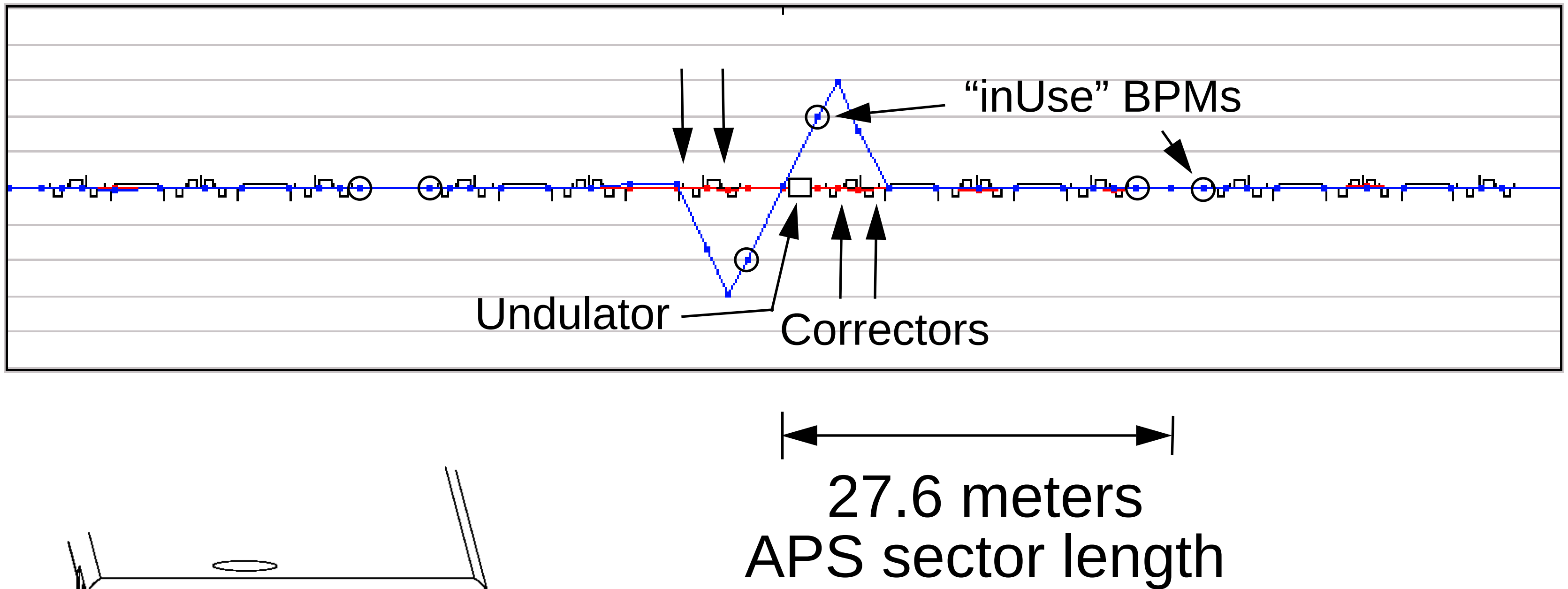
Undulator gap, cm	B_0, T	P_T for 100 mA, W	P_T for 4.45 mA, W	P_T after 7 mm filter, W *
8.00E+00	9.02E-04	5.99E-03	2.67E-04	7.31E-05
7.50E+00	1.47E-03	1.59E-02	7.08E-04	1.94E-04
7.00E+00	2.39E-03	4.23E-02	1.88E-03	5.16E-04
6.50E+00	3.90E-03	1.12E-01	5.00E-03	1.37E-03
6.00E+00	6.36E-03	2.98E-01	1.33E-02	3.64E-03
5.50E+00	1.04E-02	7.92E-01	3.53E-02	9.67E-03
5.00E+00	1.69E-02	2.10E+00	9.37E-02	2.57E-02
4.50E+00	2.75E-02	5.59E+00	2.49E-01	6.82E-02
4.00E+00	4.49E-02	1.49E+01	6.61E-01	1.81E-01
3.50E+00	7.31E-02	3.94E+01	1.76E+00	4.81E-01
2.90E+00	1.31E-01	1.27E+02	5.67E+00	1.55E+00

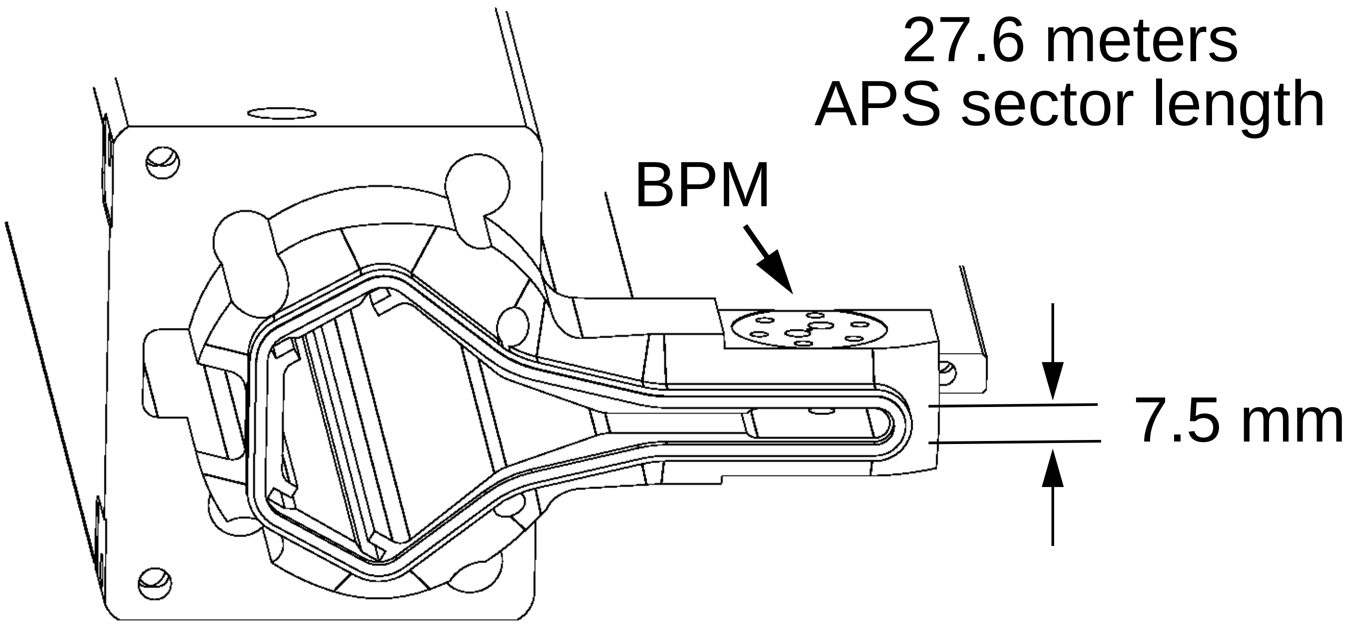
* Beryllium mass absorption coefficient = 1 cm^2 / g @ 10 keV

Insertion device gap dependence



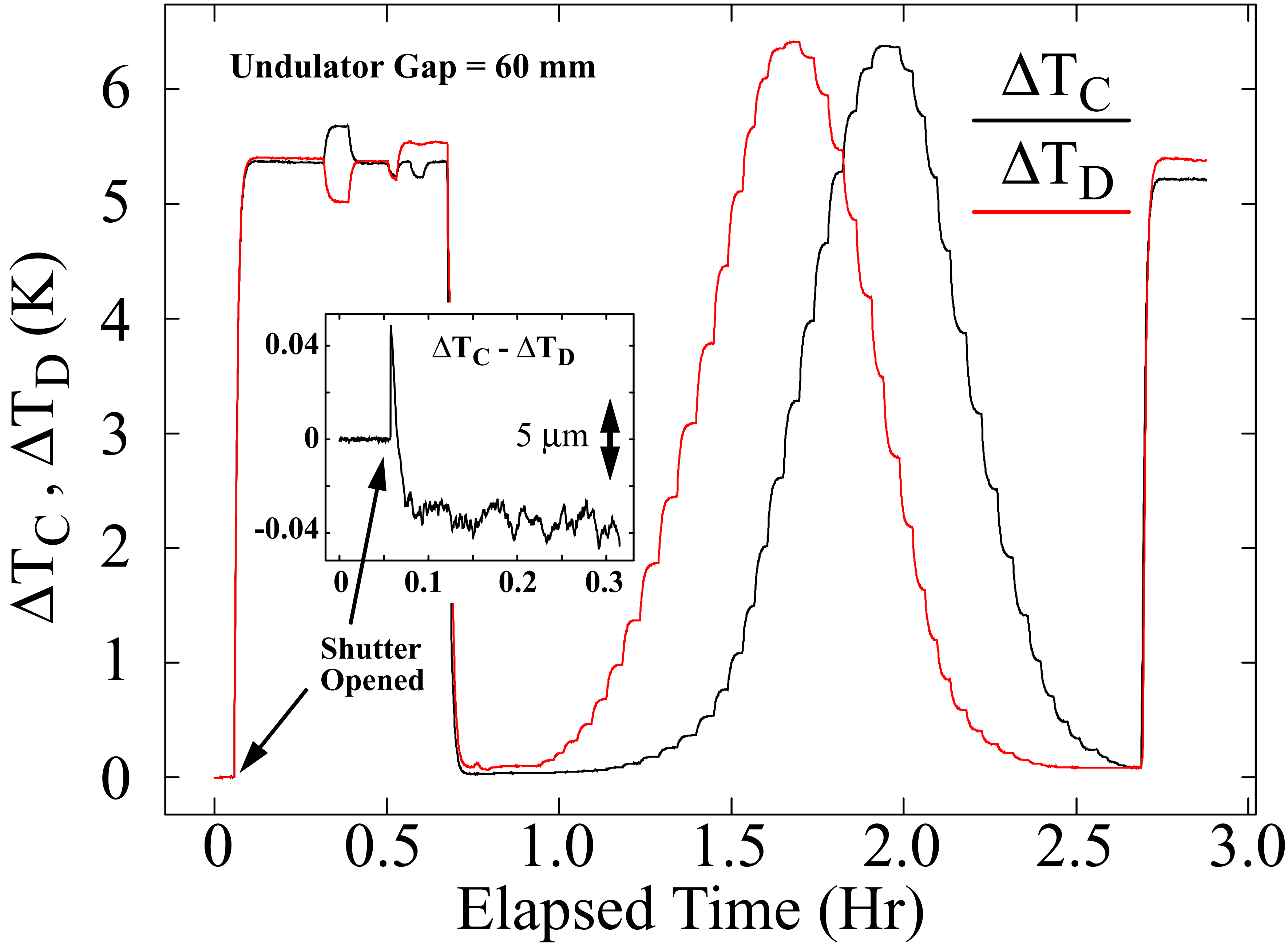
Vertical Antisymmetric 4-bump

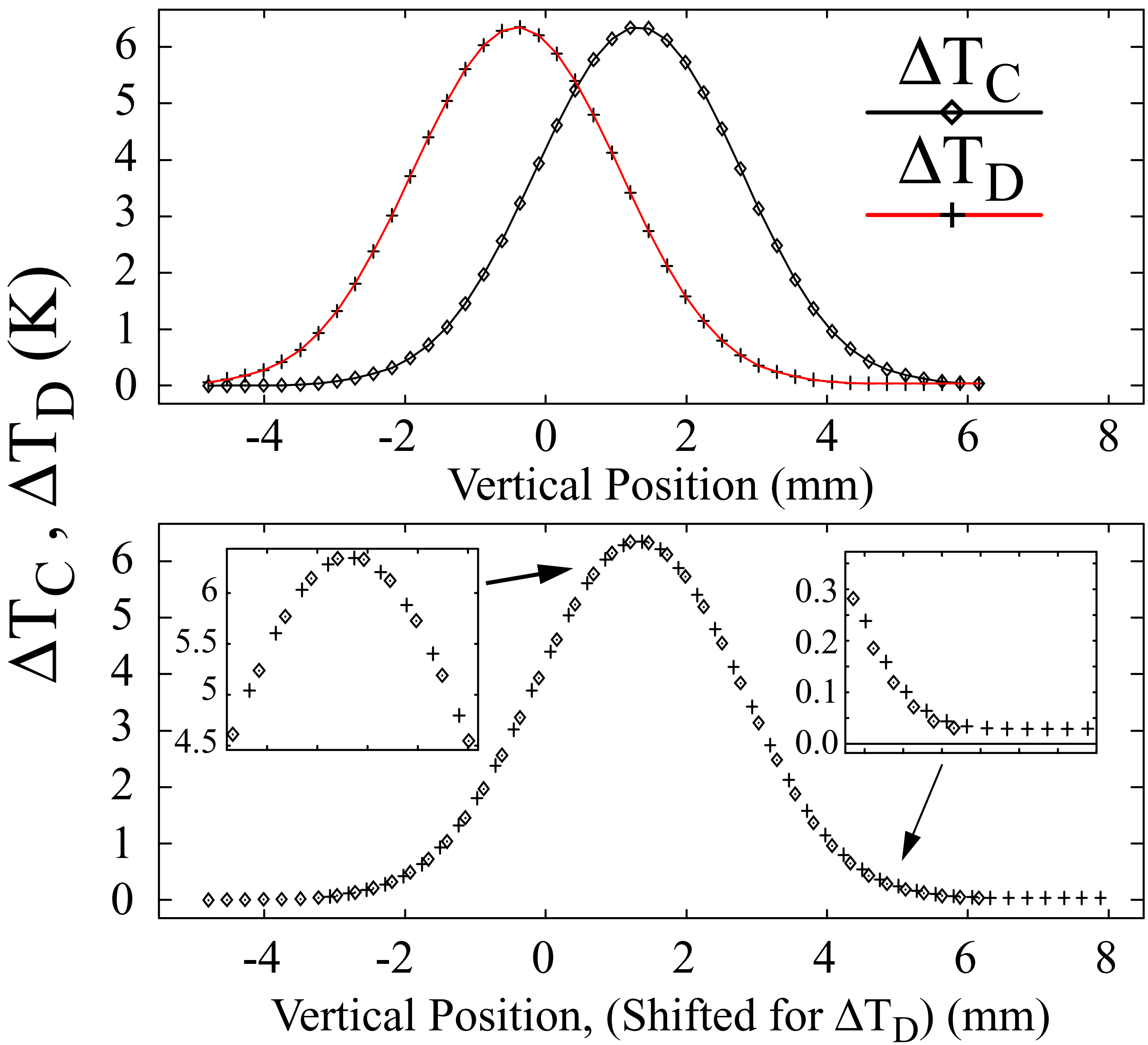




Insertion Device Vacuum Chamber

Vertical local bump scan, 5 μrad steps




ΔT_C
ΔT_D
ΔT_C , ΔT_D (K)
Vertical Position (mm)
Vertical Position, (Shifted for ΔT_D) (mm)
-4
-2
0
2
4
6
8
0
1
2
3
4
5
6
4.5
5
5.5
0.0
0.1
0.2
0.3

Conclusions

- Vibrating wire monitor is well-suited to neutral beams such as x-rays
- Device is sensitive at the level of tens of nanowatts.
- Resolution is at the level of +/- 0.001 K
- Long-term differential drift (hours) is < .01 K.
- Time constant in-vacuum is quite long - 30 seconds as tested, however,

  See S. Arutunian, "Transition Thermal Processes in Vibrating Wire Monitors", session WEPB

  Placement in air increases bandwidth considerably, at the cost of sensitivity, e.g. B.K. Scheidt, DIPAC 2005

- Implementation as an x-ray beam position monitor looks promising.

A very successful shift